Magnetic system picks up oil from spills

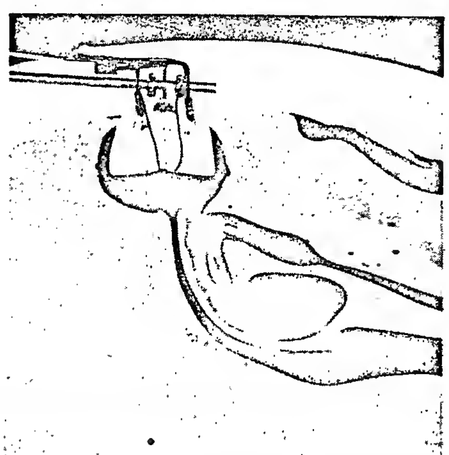
Oil-soluble ferrofluid added to test slick mixes with oil film, makes cleanup possible using electromagnet

Magnetic cleanup of oil spills using ferrofluids—in effect picking up oil in the same way a magnet collects iron filings—is being developed at the systems division of Avco Corp., Lowell, Mass. Details of the new technique were revealed to C&EN in an interview and small-scale demonstration by Dr. Robert Kaiser, leader of Avco's ferrofluids research group, and Dr. Myron A. Coler of New York University, an Avco consultant.

The Avco method imparts magnetic properties to an oil slick by adding to it a suitable oil-soluble, water-insoluble ferrofluid solution—a stable colloidal dispersion of ferromagnetic particles which do not settle or aggregate under gravity or an applied magnetic field. An electromagnet collects the oil-ferrofluid mixture.

Under study since 1963, ferrofluids have begun to find use in mineral separation, gyroscopes, seals, medical diagnosis, and other areas. Use of ferrofluids in oil spill cleanup has great potential value.

Additional stimulus to the efforts of Avco and other laboratories working on oil spill control has been given by two recent large oil tanker spills—in San Francisco and New Haven harbors—each of which poured out hundreds of thousands of gallons of oil. Increasing public outcry after every new spill and stringent oil discharge regulations issued under the Water Quality Improvement Act of 1970 add further impetus. And oil pollution incidents are starting to cost oil companies large sums, both in cleanup costs and in penalties. Yet, technology to clean up oil spills remains in its infancy.



Oil mixed with ferrofluid is collected by electromagnet in Avco laboratory tank

Against this background, Dr. Kaiser and his group began in 1969 to study the possibility of applying ferrofluids to oil spill control. The Lowell scientist points out that ferrofluids have unique physical characteristics, combining ferromagnetic properties (strong magnetic response) with regular liquid-state properties, which are retained even in a magnetic field. Ferrofluids indeed exhibit superparamagnetic behavior in the presence of an applied magnetic field.

The ferrofluid used by Dr. Kaiser for oil spill work consists of a colloidal suspension of magnetic iron oxide (either Fe_3O_4 or γ-Fe_2O_3) in a light hydrocarbon carrier oil, such as kerosine, with carefully controlled spreading characteristics. The particles do not flocculate in a magnetic field because their size is small enough (about 100 A.) for thermal agitation (Brownian motion) to exert significant dispersive influence, and because they are coated with a layer of stabilizing agent to provide short-range repulsion between particles. Oleic acid has been used in the past as a surfactant stabilizing agent to maintain particle dispersion, but the oil-control ferrofluid uses a different, proprietary agent, according to Dr. Kaiser.

Coupling. The resulting material is a liquid in which substantial magnetic forces can be produced, resulting in liquid motion. The magnetic response of a ferrofluid is due to the coupling of individual magnetic particles with a substantial volume of the surrounding carrier liquid. Coupling is facilitated by the stabilizing agent, which can both adsorb on the surface of the particle and be solvated by the carrier liquid, forming a liquid sheath of 30 to 1000 A. around each particle. Ferrofluids are stable and have a shelf life of at least one year.

San Francisco Chronicle

San Francisco Bay sea lions rest on buoy, surrounded by oil slick from tanker

In the presence of an applied magnetic field, the force experienced by each particle in the direction of the magnetic gradient is also transmitted to the bulk liquid phase, even at high dilution ratios. Thus, the Avco investigator notes, if a compatible ferrofluid is mixed with oil, the associated bulk liquid becomes magnetically responsive. Since the oil-soluble ferrofluid is not water-soluble, magnetic properties are selectively conferred on the oil phase: The collecting magnet picks up oil with very little water entrained, unlike oil-skimming methods.

Tests. Dr. Kaiser and his group

have tested their system in a large laboratory tank, but not yet under ocean conditions. In a typical lab experiment, ferrofluid is sprayed on the oil (about one part ferrofluid to five parts oil), and the magnetized oil-ferrofluid mixture is picked up by a traveling magnet.

A vacuum hose collects the accumulated oil from between the magnet poles. The oil in the gap of the magnet is not only separated from water, but is also much thicker than the oil in the slick. This increase in thickness of the oil permits use of conventional pumps to withdraw the oil to suitable containers.

System. Dr. Kaiser envisages an operational system for ocean use working on the same principles, with the collecting magnet and its supporting equipment and oil storage containers located on a specially built ship. In one example, he projects an integrated system harvesting 16 acres of oil slick per hour, or 12,500 gallons of oil of 1 mm. thickness. Removal of oil might cost much less than $1.00 per gallon, he adds. Dr. Kaiser also believes ferrofluid can be recycled to pick up further oil.

With the Avco system, Dr. Kaiser says, essentially all the oil is removed with addition of only small amounts of magnetic material. Since ferrofluids are liquids, they can be handled easily and applied to slicks by spraying. There is minimal ecological damage, since the ferrofluid additive is removed with the oil.

Another possible application, Dr. Kaiser adds, is mixing ferrofluids with oil refinery effluent streams and then passing the effluent between the poles of a magnet to clean the water of hydrocarbons. In fact, he suggests, the ferrofluid magnetic method of oil-water separation may find practical application in this area before it does in oil spill treatment.

Government and private parties step up spill control R&D

In recent months there has been acceleration of research and development efforts by government, industry, and universities to improve oil spill control methods. At least one laboratory is studying another magnetic method for oil spill cleanup, although it is quite different from Avco's use of ferrofluids.

Dr. J. E. Turbeville of the University of South Florida, Tampa, coats expanded beads of polystyrene foam with iron powder and then spreads the buoyant ferromagnetic material on an oil slick. The foam adsorbs oil and can then be collected with a magnet. However, the method—tested only on a laboratory scale—requires 10 cu. ft. of pellets for 1 cu. ft. of oil.

Surveillance. The Coast Guard carries on one of the largest oil spill research programs (C&EN, Sept. 7, 1970, page 48). Cmdr. William E. Lehr, Jr., chief of the Coast Guard's Pollution Control Branch, office of research and development, tells C&EN that the Coast Guard is now analyzing results of two years of aerial surveillance research. Test flights have been made by aircraft bearing "off-the-shelf" microwave, infrared, and ultraviolet sensors, side-looking radar (C&EN, Dec. 14, 1970, page 45), and various photographic techniques to detect and follow oil discharges.

Cmdr. Lehr hopes that by June a decision will be made to start building an experimental prototype surveillance system or systems. Regular flights over selected areas, such as New York harbor, to check visually against oil pollution have been going on for some time, and will probably be stepped up even before sensors become available.

The Coast Guard's oil transfer, containment, and collection programs are phased about a year apart, according to Cmdr. Lehr. The air-deliverable antipollution transfer system (ADAPTS), involving transfer of oil from a stricken tanker to large rubber bladders (C&EN, May 25, 1970, page 15), has been tested in prototype in both calm and rough waters, and is now undergoing final modification. Cmdr. Lehr says procurement is planned of the first full-scale system by July, with deployment probably on the East Coast soon thereafter.

In its oil containment program, the Coast Guard awarded a $1 million contract to Johns-Manville Corp., New York City, to build a full-scale prototype oil containment boom system. The system will be based on conclusions of previous design studies and of hydrodynamic investigations on oil movement and boom functioning. Required to be air-deployable and to contain oil even in 5-foot waves, the system is to be ready for sea testing in late spring.

As for high seas oil-collecting devices, the Coast Guard will decide within the next two months on contracts to design oil-recovery equipment.

Biodegradation. Another federal agency, the Office of Naval Research (ONR), is encouraging research on accelerated biodegradation of oil. Allen Jewett, naval biology project officer, says that ONR is assisting at least seven scientists in this work.

The American Petroleum Institute (API) oil spill program is also accelerating, according to research program coordinator Jack R. Gould. A study will be released shortly, prepared for API by Arthur D. Little, Inc., Cambridge, Mass. The study discusses selection of oil spill treatment agents appropriate to different environments.

Approved For Release 2002/06/19 : CIA-RDP88R00729R000200030014-9